OLQ Geological Services
Technical Memorandum
September 9, 2000

Lead Issues at Small Arms Firing Ranges

Introduction

Lead is a bluish-gray metal which has been mined and utilized for thousands of years. Its use in batteries, plumbing, gasoline and paint; and the adverse environmental and health effects associated with those uses, are well known and much publicized. The Indiana Department of Environmental Management (IDEM) has several programs in place to protect human health and the environment from the adverse effects of lead from these sources. In response to questions received about the potential adverse environmental impacts of lead deposited at outdoor shooting ranges, IDEM has prepared this guidance to address the environmental and legal issues involved. These ranges may be public or private and operated by individuals, gun clubs, the military, state and local police departments, Olympic and Pan Am Games shooting committees, or the Indiana Department of Natural Resources. Due to the low mobility of metallic lead from spent ammunition, adverse effects are rare and site specific, however, re-use of range land is a concern of IDEM.

Lead is the primary projectile component of ammunition used in handguns, rifles and shotguns. Lead bullets and shot may be pure lead or may consist of lead alloys containing very small amounts of tin and antimony. In many cases the lead bullet is covered with a copper or steel jacket or covering. Shot used in shotguns may be made of non-toxic steel or bismuth. Clay targets and plastic shotgun wads are also among the materials found at shooting ranges.

Rifle and pistol ranges are generally designed so all shooting is done in one direction and usually into a earthen berm or hillside for safety sake. In such cases, spent bullets are usually limited to a relatively small area. Lead shot, clay targets and wads are generally much more widely dispersed at trap, skeet, and sporting clays ranges since these games require shooting shotguns in many directions at moving targets.

Legal and Regulatory Issues

At present there are no environmental regulations or statutes which specifically address outdoor shooting ranges. Because of the increased public awareness of adverse health and environmental effects of lead, there have been several lawsuits filed against range operators in state or federal courts, alleging violation of various statutes, regulations or environmental harm. In 1988, a lawsuit was filed in Indiana alleging that a shooting range violated hazardous waste rules, developed from the Resource Conservation and Recovery Act (RCRA). In response, the Indiana Department of Environmental Management sought the opinion of the United States Environmental Protection Agency on the matter. Their opinion was expressed in a September 6, 1988 letter to IDEM. This position was recently reiterated in the federal register on February 12, 1997 on page 6630 and remains from the 1988 letter. The position expressed in the EPA letter and preamble is the position IDEM has maintained in all matters relating to shooting ranges, as follows:

> Our office interprets the hazardous waste regulations as not extending to products whose use involves application to the land, or where use necessarily entails land application, when those products are used in a normal manner. The use of munitions (lead bullets, lead shot) does not constitute a waste management activity because the munitions are not "discarded." Rather the firing of munitions is within the normal and expected use of the product. Lead bullet and lead shot impact areas at small arms firing ranges are likewise not regulated by the hazardous waste regulations since hitting and remaining on the ground is a normal expectation of their use.

The practical application of this interpretation is that operators of shooting ranges would only be potentially subject to hazardous waste regulations if they generate a hazardous waste, in which case they would be regulated no differently than any other type of generator. There are no hazardous waste rules under RCRA Subtitle C or in state rules, which require the clean-up of lead bullets, shot, or other debris (e.g.,clay targets) from firing range impact areas. If a shooting facility does clean up spent munitions, debris, or soils for disposal; they would be subject to any applicable solid or hazardous waste rules for disposal of that material. Small arms firing range debris destined for disposal would only be considered hazardous if it exhibited any characteristic of hazardous waste. A representative sample of the waste would have to be evaluated to determine if it met characteristics. Our experience is that the materials will often exhibit the toxicity characteristic for lead, when tested using the toxicity characteristic leaching procedure (TCLP) (see Appendix A). If sufficient lead is present to make reclamation feasible, lead bullets and shot would be considered scrap metal, and would be exempt from the hazardous waste rules if destined for reclamation.

Regardless of the lack of specific regulations, lead is a hazardous substance. If a given range is having adverse effects on the environment, lawsuits may be filed to seek remedies under broader " imminent hazard" provisions of RCRA Sections 7002 and 7003; the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA); or state laws. These lawsuits may be initiated by private citizens or government agencies. This environmental threat (or perceived threat), and the resultant liability or fear of liability is a factor which drives some clean-ups of shooting ranges. Property transfers of range land can also be hindered by this liability, which may include future owners. Clean ups are sometimes performed to facilitate the sale of property. Remediation requirements should be determined on a case-by-case basis, taking into account site-specific risks and the planned reuse of the property.

Re-use of property is the primary reason IDEM has recommended remedial actions at closing ranges. In one case, a housing development was planned in the lead contaminated area. IDEM intervened. Any situation where children are directly exposed to contaminated soil from shooting ranges merits special concern and remedial action. In other situations, a site-specific evaluation to determine the risk posed (if any) is necessary to determine recommendations. Factors to consider in this evaluation, and general recommendations, are discussed in the remainder of this guidance.

Indiana Site Conditions

Although many factors affect the mobility of lead (see Appendix B), it has not been a problem in site conditions normal to Indiana. Lead bullets and shot will oxidize at a very slow rate to produce soluble compounds which can be somewhat mobile, but these forms will readily absorb to the clays, iron and manganese-rich sediments, carbonates, sulfur compounds and organic matter common to Indiana soils.

Rainwater in the Midwest is slightly acidic. This will solubilize lead and increase mobility. However, the buffering action of soils and groundwater will quickly neutralize acid rain. In Indiana the only place where persistent acidic conditions are found is in coal mine drainage, marshes or swamps. A firing range in such an area might produce localized high dissolved lead levels, but this would be balanced by the low water flow conditions, high sediment levels, and high organic contents.

Surface or ground water pollution from firing ranges has not been a problem. Firing range lead does not migrate far from the source. Case studies have found that even in areas of extremely high shot density, most of the soluble lead absorbed to sediments or settled out within a short distance. No normal off-site transportation of lead via neutral to alkaline surface water has been observed (EA Engineering, Science, and Technology, 1996).

Health and Toxicity

For lead to be toxic to animals or humans, it must enter the body. The exposure pathways of concern for lead are inhalation and ingestion. Inhalation can be a factor when significant amount of airborne lead dusts and fumes are present, such as around lead smelters and recycling centers. Small, poorly ventilated indoor ranges firing large volumes of non-jacketed lead bullets into steel backstops have occasionally presented risks from inhalation for range employees upon long term exposure. Excavation of the impact areas of a range could possibly generate lead dusts, so dust control measures should be used. Normally, lead inhalation at outdoor ranges has not been found to present a problem, because the amount of lead dust produced by outdoor firing ranges is very limited.

This leaves ingestion as the major pathway for toxic lead effects from a firing range. Drinking water is seldom affected by firing ranges because of the low solubility and restricted migration of metallic lead. Therefore, eating of lead or lead contaminated soils is the health risk normally encountered.

Pre-school children are the most vulnerable to lead toxicity because lead absorption in the gastrointestinal tract is greater for children than adults, children's nervous systems are more susceptible to neurotoxic effects, and children are much more likely to be in contact with, and eat, soil. If there is no contact, then there is no possibility of ingestion. A good vegetative cover helps prevent contact, but children should not be allowed to play in range impact areas.

Forms of Lead

Most of the cases of severe lead poisoning in children are due to exposure to lead-based paints or leaded gasoline residues, and this is the focus of much of the research and articles on lead toxicity (Xintaras, 1992; Mielke, 1999). These reports can not be related to firing ranges. Lead from a firing range is much less toxic because there are direct relationships between toxicity and lead particle size, plus chemical form. Firing range lead is in metallic form, mostly as whole or fragmented bullets, with only a small amount of dust-sized particles. The larger particles are not as readily absorbed (Colorado Dept of Health, 1990). Leaded paints normally form dusts from the paints' flaking, weathering, and chalking, which are readily absorbed into the body. Also, the lead in paints exists in the form of oxides or salts, which can be over ten times more absorbable than metallic lead. (Xintaras, 1992) Lastly, lead from paint concentrates in and around the house, where contact is unavoidable, and ingestion common.

Ecological Risks

Smaller lead particles (shot or fragments) can be ingested by wildlife, usually when mistaken for seeds or consumed by fowl looking for gizzard grit. Even one pellet may prove toxic to some birds, so precautions should be taken to make range impact areas uninviting to wildlife. This is a particular problem for waterfowl feeding in ponds, which is why there is a ban on lead shot for waterfowl hunting, and why firing ranges should not have open water in or near impact areas.

Fruit trees, grains, and other vegetation providing wildlife foods should not be located on firing ranges. Even grasses may prove a problem as ducks and geese prefer to graze in close-cropped grasses and may dig several inches into the soil. Range impact areas should not be closely mowed. Denser, low shrubs and bushes should be encouraged. If grasses are planted, they should be allowed to grow knee to waist high to discourage rooting wildlife.

Land Reuse

Future land use is the most important factor in determining if remediation is necessary. Is the range to be used for farmland, residences, industries, or a park? The type of re-use will determine if cleanup is needed to mitigate future lead exposure.

The goal of remediation is to prevent lead from harming humans or the ecology. Since ingestion is the exposure pathway of concern, the remediation method must prevent contact and possible ingestion of the lead. Obviously, a parking lot or industrial use will not present many

opportunities for contact and ingestion; while residential use, with children playing and digging in the dirt, could pose a definite problem.

Reclamation

The most final and complete remediation is to remove the contamination and leave the site clean. If the lead fragments are distributed so that they can be gathered up, this option should be considered. This is most feasible if the lead is concentrated in small areas. In the case of a rifle or pistol range, most of the lead will be in the backstop behind the targets. Simple, limited excavation and sieving of the backstop impact area will remove most of the lead.

Shotgun ranges (trap and skeet) present a more difficult problem because the lead pellets are more wide-spread, but do not penetrate far beneath the surface. There are machines, however, that remove the top few inches of soil, extract the lead, and replace the soil. These are often used at large ranges to recover and recycle lead shot.

There are firms which specialize in lead cleaning at firing ranges. Some of these are listed in "Environmental Aspects of Construction and Management of Outdoor Shooting Ranges." If a large range is being closed, it may be worth calling a specialist. A small range may be cleaned by just a few people with shovels and sieves.

Waste Handling

Once the lead is separated from the soil, it can be taken to a metal recycler. This is not hazardous waste disposal, as metal recycling is exempt from the hazardous waste rules (Bruce Palin letter, Appendix C.) The only regulatory problem would be in the excavation and removal of contaminated soil and/or debris as waste material.

If debris or soil is removed from the site, the Federal Hazardous Waste Rules will apply. The waste sent off-site for disposal would be considered hazardous if the required toxicity characteristic leaching procedure (TCLP) test determined it above regulatory limits for lead, in which case the waste must be handled and disposed of under the hazardous waste rules. This can be extremely expensive, so it is usually more feasible to extract the lead and send it to a recycler, or to manage it on site.

Site Management

If it is impractical to remove the lead, it may be successfully managed on-site. The key idea is to prevent migration and contact, to prevent possible ingestion. As listed above in the section on Lead Mobility, clay and phosphates help to bind up lead, so applications of phosphate fertilizers and covering with clay soil are quite beneficial. A sufficiently thick soil cover, if seeded and maintained so there are no erosion problems, will help prevent contact with lead.

Examples

The amount and type of remediation needed depends on specific site conditions - how much lead, how it is distributed, drainage, soil types, and what the future land use will be. The following are

just general suggestions for hypothetical sites, as to what may be appropriate in some cases; not absolute guidelines, which are impossible to set without knowing site specific information.

Example 1; A small, neighborhood rifle and shotgun slug range on a farm: It is an informal range, just a dirt bank on a section of hillside. Almost all of the bullets are concentrated in a small area, and a few are exposed on the surface due to erosion. The range is to be closed and the land is to continue as farmland and pasture . This site could be adequately controlled by hand excavation and sieving of bullet fragments, cleaning up the impact area, covering it with additional soil, reshaping the bank into a stable slope, and seeding it with grass.

Example 2; A large club area with multiple rifle and pistol ranges, plus several trap and skeet ranges: It has been re-zoned for industry, and the new owner plans to build a shopping center and office park. Most of the area is to be covered by buildings or pavement. The cover will prevent contact and exposure pathways, so the main concerns are to see that the lead impact areas are indeed covered by the paved or building areas, and that any building excavation or grading plan takes lead contamination into account. If soil is excavated from contaminated areas, it will need to be tested if it is taken off-site. Grading will need to be performed so lead areas are covered and contained, and not spread further across the site.

Example #3; A large trap and skeet club, with a small lake in the lead impact area: The property is to be made into a park. Since children will be playing in the dirt, more care is needed to prevent exposure. The impact areas need to be defined and the lead removed as much as possible. Some of the lead sifting machines should be considered for this. After reclamation, the area should be covered with a six inch layer of clean fill, and reseeded. To protect wildlife and children, the small lake should be dredged and cleaned, or filled in-place.

Example #4; A small to medium size rifle and pistol range, which the new owner wishes to turn into residential property: For residential re-use, property must be as close to risk free as possible. Children can be expected to spend great amounts of time around their homes, and the opportunities for digging and ingesting contaminated soils are much higher. Depending on site conditions and contaminant distribution, this re-use may not be recommended. Extensive cleaning and lead reclamation would be needed, plus a thick cap on the impact areas. It may not be economically feasible to do all this necessary work.

Example #5; A medium-sized trap and skeet club which intends to stay open, but wants to prevent negative environmental impacts: The club should set up an environmental management program; with a plan for lead recovery and recycling, range management, erosion prevention, etc. The “Environmental Aspects of Construction and Management of Outdoor Shooting Ranges” outlines the steps needed for such a program.

CONCLUSION

Small arms firing ranges do not present extreme environmental hazards, nor are extensive remediation efforts usually required. Depending upon the site conditions; localized, small scale cleanups or cover may be adequate. It is recommended that active ranges have an environmental management program to control lead contamination, and recycle spent materials.

REFERENCES

Colorado Department of Health (1990). Leadville Metals Exposure Study. University of Colorado at Denver, Agency for Toxic Substances and Disease Registry.

EA Engineering, Science, and Technology, Inc. 1996. "Lead Mobility at Shooting Ranges." Sporting Arms and Ammunition Manufacturers Institute, Newtown, CT.

Mielke, H.W. 1999. Lead in the Inner Cities. American Scientist 87: 62-73.

"Environmental Aspects of Construction and Management of Outdoor Shooting Ranges" 1997. National Shooting Sports Foundation, Newtown, CT.

Xintaras, C. 1992. Impact of Lead-Contaminated Soil on Public Health. U.S. Department of Health and Human Services

APPENDIX A

CHEMICAL TESTS

APPENDIX A

Chemical Tests

In order to establish a valid method for determining the possible extent of lead impacts on areas surrounding shooting ranges, it is necessary to use appropriate analytical models. Although lead is basically immobile in the environment, there are certain forms which can be mobilized, and therefore, have the potential to impact areas other than the immediate vicinity of the shooting range. A commonality of these forms of lead is their solubility in water or acids.

Leach modeling is the most appropriate method to assess the mobility of lead. Leach models act as a gauge of the totality of mobile lead. For the purposes of truly assessing mobility and contaminant risk in a site specific area, several other factors must be identified and accounted for. Average rainfall amounts, infiltration rates, soil cation exchange capacities, existence of lead-reactive ionic species, total volume of the area of interest, etc., must be considered in order to determine the level of risk associated with a shooting range site.

The model most commonly considered for use is the toxicity characteristic leaching procedure (TCLP), EPA SW-846 method 1311. This model is used to determine whether leachable lead levels exceed regulatory thresholds, and are considered hazardous for the purposes of disposal. This model was designed to mimic leachate generated in a solid waste landfill, which accepts organic and inorganic wastes. These organic wastes may decompose, with attendant acid formation, which increases the likelihood of metal ion solubility. The premise behind the model makes it a poor candidate for assessing the level of leachable lead at a firing range, because the amount and type of acids the model uses typically would significantly exceed those types and amounts found naturally.

Water leach models, similar to the Indiana Neutral Leaching Method or the ASTM Water Leach Method, are more appropriate than TCLP, as they tend to reflect a more real estimate of the acidity encountered in the environment. The main shortcoming of these models is their use of distilled, deionized water, which does not exactly mimic the buffered water systems found in the environment. For shooting ranges over a standing body of water, such as some shotgun ranges, this would be the most appropriate leach model to assess the amounts of lead which may become mobile. Although rain would feed the standing water body, directly or indirectly, the size and buffering capacity of the standing water body and its matrix would cause the pH of the influx water to rapidly approach neutral.

Given the acidic nature of rainfall in Indiana, the leach model which could be considered appropriate for most shooting ranges would be the Synthetic Precipitation Leaching Procedure (SPLP), SW-846 method 1312. The vast majority of water that would be in contact with lead from the majority of shooting ranges would be encountered as rainfall. The pH of rainfall in Indiana ranges from around 4.5 to 5 standard units. The leach fluids stipulated for this model simulate the acidity and types of acids noted in rain. The leach fluid appropriate for determining lead mobility in Indiana has a pH of 4.2 ± 0.05 standard units, and would effectively model a worst-case scenario of lead mobilized by the effects of acid rain.

APPENDIX B

LEAD MOBILITY

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Lead Mobility

A number of factors affect the mobility of lead in the environment. A partial list of the factors which affect lead in the environment follows.

- Lead oxidation is very slow (100 to over 300 years) for bullets, depending on site conditions.

- Cation exchange capacity: In soils, the ability to exchange cations binds lead into the soil matrix, but the process is reversible when new cations are introduced into the system.

- Sulfides: Sulfur has a high affinity for lead, which, after reacting to form lead sulfide, precipitates out, moving contamination from water into the sediments. In sediments, sulfides cause free lead to become effectively insoluble, preventing transfer into water resources by dissolution.

- Sulfites and Sulfates: In the presence of water-soluble sulfites/sulfates, lead tends to precipitate out of solution. Soils high in sulfites/sulfates will cause lead to become effectively insoluble, preventing transfer into water resources by dissolution. Depending on the amount of free oxygen present, sulfites tend to slowly oxidize to the sulfate species.

- Phosphates: Phosphate ion sources tend to be quite effective in immobilizing lead. Lead phosphate is insoluble, and is quite stable. Phosphate fertilizers can help immobilize lead.

- Hydroxides: Free lead, in the presence of hydroxide ions, forms lead hydroxide, which is insoluble.

- Humic substances: Lead forms complexes with these high molecular weight compounds, reducing their mobility and solubility.

- Carbonates: Lead/carbonate interactions decrease the solubility of lead.

- Acids: Lead is soluble in dilute acids.

- Clays and iron or manganese oxides are highly lead absorbent, which restricts mobility.

APPENDIX C

PALIN LETTER

State Form 4326

DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

INDIANAPOLIS

OFFICE MEMORANDUM

Date: July 3, 1997

To: John Rose
Assistant Commissioner
Office of Environmental Response

From: Bruce Palin BNP
Acting Assistant Commissioner
Office of Solid and Hazardous Waste

Subject: Small Arms Firing Range Accessment Workgroup,
RCRA Applicability to Fired Munitions

Our OSHWM representative on the Small Arms Firing Range Accessment Workgroup (FRW) has asked that I communicate OSHWM's policy with respect to the applicability of Indiana's Hazardous Waste Rules and Laws to small arms firing ranges. It is my understanding that your office is developing a guidance document to deal with the issue of lead deposition and clean up recommendations at shooting ranges.

Coincidentally, the U S. EPA has recently published a final rule regarding military munitions on February 12, 1997. Although this rule is applicable only to military ranges the preamble to this final rule on page 6630 (copy attached) discusses the EPA's position on Resource Conservation and Recovery Act (RCRA) applicability to non-military ranges. Their position was actually first expressed in a 1988 letter to this office from EPA in response to our inquiry The positios expressed in the letter and preamble is the position this office has maintained in all matters relating to shooting ranges. The discharge of bullets and shot at shooting ranges does not constitute solid waste or hazardous waste disposal. To be regulated by our office under the solid or hazardous waste rules a material has to be a solid waste. Nothing in our Indiana statutes or rules suggest that our jurisdiction over shooting ranges is any different than under RCRA. Indiana's statutory definition of solid waste at IC 13-11-2-205 mirrors the federal definition under RCRA at 42 USCA 6903 Sec.1004(27). Federal regulations implementing this definition at 40CFR 261.2 have been adopted by reference in Indiana's hazardous waste rules at 329 IAC 3.1-6.

Our office interprets the hazardous waste regulations as not extending to products whose use involves application to the land, or where use necessarily entails land application, when those products are used in a normal manner. The use of munitions (lead bullets, lead shot) does not

constitute a waste management activity because the munitions are not "discarded." Rather the firing of munitions is within the normal and expected use of the product. Lead bullet and lead shot impact areas at small arms firing ranges are likewise not regulated by the hazardous waste regulations since hitting and remaining on the ground is a normal expectation of their use.

The practical application of this interpretation is that operators of shooting ranges would only be potentially subject to hazardous waste regulations if they generate a hazardous waste, in which case they would be regulated no differently than any other type of generator.. There are no hazardous waste rules under RCRA Subtitle C or in our rules, which require the clean-up of lead bullets or shot or other debris (e.g.,clay targets) from firing range impact areas. If a shooting facility does clean up spent munitions, debris or soils for disposal they would be subject to any applicable solid or hazardous waste rules for disposal of that material. Small arms firing range debris destined for disposal would only be considered hazardous if it exhibited any characteristic of hazardous waste. A representative sample of the waste would have to be evaluated to determine if it met characteristics. Our experience is that the materials will often exhibit the toxicity characteristic for lead when tested using the toxicity characteristic leaching procedure (TCLP). If sufficient lead is present to make reclamation feasible, lead bullets and shot would be considered scrap metal and would be exempt from the hazardous waste rules if destined for reclamation.

The military munitions rule finalized by the US EPA on February 12, 1997 addresses all military munitions, not just small arms ranges which is the focus of the FRW. Our office is proceeding to adopt this rule with no changes at present. I trust that the above shall be sufficient information for the purposes of the FRW and will be reflected in the guidance being developed. If I or my staff may be of further assistance please let me know.

DWB
attachment

cc: Tom Linson
Jim Hunt
Mike Dalton
Richard Milton
Tom Neltner
Firing Range Workgroup